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TANK WARS GENERAL INFORMATION MANUAL

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

This report describes a computerized Monte-Carlo model of combat between as many as 20 armored vehicles. It gives general information at the management level rather than going into details of the model.

The model includes the simulation of these features: individual round or burst firing; various target switching policies; M, F, MF, and K kills; firing-signature and nonfiring detections; and three levels of acquisition including the hunter-killer concept. The model provides for multiple levels of output

Block 20 continued:

including Event Histories for individual replications as well as more detailed and more aggregated levels of output.

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INTRODUCTION

This report describes a model of combat between armored vehicles. The report is for general information and does not go into details of the model. It should be useful to those who want a quick introduction to the model at the management level and to those who are planning to use the model but first need a good overview.

The model treats any armored vehicle but for brevity the report calls them all tanks.

The TANK WARS model simulates combat between 20 or fewer tanks grouped into two forces called Blue and Red (B&R). The model plays such tank characteristics as burst fire, various target switching policies, Hunter-Killer, and four levels of kill.

The model is easy to understand because it is a Monte-Carlo model which simulates each significant event in the engagement. The randomly generated events are printed in an event history if desired, so they can be studied in detail.

To put this in perspective, there are basically two ways of analyzing combat; either move through the engagement while keeping track of the distribution of all possible intermediate outcomes or move through the engagement each time selecting a single outcome and repeat this for enough engagements to produce a statistically significant picture of the distribution of final outcomes. The first method involves the complex convolution of many distribution functions and is impossible for the layman to trace. It is also difficult to modify and extend. The second method is very easy to trace because a simple event history can be examined. It is also fairly easy to extend such models.

INPUT REQUIREMENTS

The model requires three sets of information, probability of kill given a hit (Pkh), delivery errors, and some miscellaneous information. The Pkh data comes from the Vulnerability/Lethality Division, Ballistic Research Laboratory, and consists of sets of tables which give Pkh for the dispersions, ranges, kill criteria, target exposure, target orientation, round type, and target type. The dispersions are from 1 to 10 ft standard deviations of the normal distribution on the target and for the uniform distribution on the target. The ranges are from about 500 m to 3000 or 3500 m. The kill criteria for both hull defilade and fully exposed targets are mobility kill (M-kill), firepower kill (F-kill), mobility and firepower kill (MF-kill), and catastrophic kill (K-kill). The target orientations tabulated are for rounds striking the target at aspects of 0 to 180 degrees in increments of 30 degrees.

The delivery accuracy data is a set of tables which give fixed bias, variable bias and dispersion horizontally and vertically. These errors are tabulated as a function of target range and either position in the burst or result of the previous round. In the case of tanks firing individual rounds, the errors for each round vary depending on whether it is the first round fired or if it is fired after a lost miss, a sensed miss, or a hit. In the case of burst fire, data is sometimes available to ascribe different sizes of errors depending on the position of the round in the burst.

The miscellaneous inputs are the dimensions of the tank, the ammunition load, the time of flight of the projectile versus range, parameters which define the distribution of detection times, and the parameters which define the firing cycle of the tanks.

MODEL DESCRIPTION

The model pits two homogeneous forces against each other. All the tanks on a side are identical to all the other tanks on that side in vulnerability, range to the enemy, initial load of rounds, exposure, sensors, and firing cycle. They differ only in initial orientation. Either side may be fully exposed or in hull defilade.

Initiation of Engagement

When the simulation of a single engagement begins the model takes a number of actions. All the tanks of the Blue side are given a prescribed number of rounds, may be placed in hull defilade and each is randomly oriented by some distribution of attack angles. Then the model randomly finds when each Blue firer would detect each Red target (assuming the Red targets are not firing). Next each Blue firer is tentatively scheduled to detect the Red target which was given the most immediate detect time. In other words, for each Blue we find the minimum of the detection times for each of the Red targets. The model takes a similar set of steps for the Red side.

Detection

Whenever a tank begins to search for a new target the model tentatively schedules a nonfiring detection on one of the new targets (if there are any). The detection time is a random time. It is drawn from distributions provided by US Army Material Systems Analysis Activity and US Army Night Vision and Electro-Optics Laboratory.

In addition to nonfiring detection, a target may be detected because of its signature during firing. This is called firing signature detection. The model treats it as follows: Anytime a tank fires the model checks all enemy tanks. If the enemy tank is searching for a target the model rolls a random number to see if it detects the firing and depending on the random number schedules a firing signature detection immediately and cancels any pending nonfiring detection.

The model plays three levels of detection for subsequent targets. In the first method the tank commander and gunner begin searching for a new target after servicing the current target. In the second method the tank commander begins searching after the first trigger pull on the current target. And in the third method the tank commander begins searching for a new target immediately after the current target is detected.

Target Switching Policies

The model plays three target switching policies. A firer disengages from the current target and attempts to engage another target depending on the policy set by the model user. Under policy 1, the target is serviced if it is K-killed. Under policy 2, the target is serviced if it is hit and under policy 3, the target is serviced if the firer fires a fixed number of rounds at the target or it is K-killed, whichever happens first. This assumes the firer is not firing bursts; if the firer is firing a burst, the burst must be completed before disengagement.

If a new target is "on deck" the firer switches to it; otherwise two things happen. First, searching for a new target begins. Second, the model schedules the reengagement of the oldest surviving enemy target. This allows for the possibility that there are not any new targets but some old targets are available for further servicing.

Kill Criteria

When a round impacts, there are four possible outcomes: The round may miss and be sensed or not, the round may hit but not kill, or the round may hit and cause one of four levels of kill. The levels of kill are M or mobility kill, F or firepower kill, MF or mobility and firepower kill, and finally K or catastrophic kill.

The model, currently, simply records mobility kills. It could be immediately upgraded to set the velocity of the target to zero so that the appropriate error budget table would be used for computing whether a hit occurs.

In case of an F-kill, the target is not allowed to fire any more rounds during the engagement. Rounds which were fired before F-kill continue on their flight. It is these rounds in flight which cause "simultaneous" kills and may result in an all-dead outcome. They are not as unlikely as might be expected.

A K-kill is defined to be damage to a vehicle which is so severe it's not economical to repair it. In practice all K-kills are MF-kills but not all MF-kills are K-kills. In the model (and in combat models in general) we make an assumption which was not unwarranted in the past

but which is probably unwarranted for certain tanks now being fielded. The assumption is that a K-kill is a signal to all firers that the target is killed and will no longer be fired upon.

<u>Win Criterion</u>

Currently, Blue wins if all Red targets are K-killed and at least one Blue is not K-killed. Similarly for Red. This win criterion is rather severe; in the future we will probably substitute a kill at the F-kill level.

<u>End of Engagement Criteria</u>

The engagement ends if tmax seconds have elapsed (sometimes set to 600 s), or if all tanks on one side are K-killed, or if no tanks can fire anymore. This last criterion is met either by running out of ammunition or by suffering F-kills.

<u>Motion</u>

The model currently simulates stationary firers and stationary targets. It can handle motion only in a limited sense. Motion has four basic effects. First, motion causes the range between combatants to change. This is not modeled at all; the range is selected at the beginning of the run and is constant throughout. Second, motion of the firer introduces aiming errors. The model is capable of simulating this by using error budgets which are available for some (but perhaps not all) systems of interest. Third, motion of the target introduces aiming errors. The model is capable of simulating these errors for a constant velocity target by using error budgets, some of which are available for some conditions of interest. Fourth, motion changes exposure. The model doesn't handle this currently.

OUTPUT

The model generates several levels of output. At the most general level, the model prints a half-page summary of all replications of a given engagement. The summary includes:

Fraction Blue wins	Fraction Red wins
Fraction drawn (all dead)	Fraction drawn (B&R alive)
Mean Blues killed	Mean Reds killed
Mean Blue rounds fired/tank	Mean Red rounds fired/tank
Exchange ratio	

For engagements with up to two Blue tanks and three Red tanks, information is tabulated for each of the 3 by 4 = 12 outcomes. The information tabulated is number of Blue wins, fraction of Blue wins, mean Blue ammunition expenditure per tank, mean Red ammunition expenditure per tank, and mean duration of the engagements. These outputs are shown in Table 1 for a typical case.

TABLE 1. SAMPLE OUTPUT

CASE = 75

3 RED TANKS ATTACK 2 BLUE TANKS. 100 replications

Range = 1500 meters

0.89	fraction blue wins	0.44	mean blue tanks dead
0.11	fraction red wins	2.77	mean red tanks dead
0.00	fraction b8r alive	4.51	mean blue rds used
0.00	fraction all dead	1.35	mean red rds used
6.30	exchange ratio		

 # OF OCCURENCES

#	2	4.00	4.00	3.00	0.00
blue	1	0.00	0.00	0.00	22.00
dead	0	0.00	0.00	0.00	67.00
		0	1	2	3
			# red dead		

FREQUENCY

#	2	0.04	0.04	0.03	0.00
blue	1	0.00	0.00	0.00	0.22
dead	0	0.00	0.00	0.00	0.67
		0	1	2	3
			# red dead		

MEAN BLUE RDS USED

#	2	3.63	2.75	3.83	0.00
blue	1	0.00	0.00	0.00	5.11
dead	0	0.00	0.00	0.00	4.50
		0	1	2	3
			# red dead		

MEAN RED RDS USED

#	2	1.92	2.08	2.11	0.00
blue	1	0.00	0.00	0.00	1.64
dead	0	0.00	0.00	0.00	1.14
		0	1	2	3
			# red dead		

MEAN DURATION (sec)

#	2	35.9	34.6	56.2	0.0
blue	1	0.0	0.0	0.0	56.9
dead	0	0.0	0.0	0.0	38.9
		0	1	2	3
			# red dead		

The model can also print a very detailed output called an Event History. The Event History lists the time each event occurs and tells what happens at that event. For an individual engagement with just a few combatants, the model may print several pages of event history, for each of say 500 replications, so this information is not generally saved. But the event history can be extremely useful for spot checking the model and for understanding exactly what is going on during the engagement. The interactions between combatants are not obvious sometimes.

There is another level of detail which is of interest. At this level not only is each event printed as it happens, events which are tentatively scheduled are printed when they are in fact scheduled and if they are later cancelled, the cancellation is printed when it occurs. Table 2 shows output at this level of detail.

TABLE 2. EVENTS SCHEDULED, CANCELLED AND EXECUTED

```
        CASE =   7

          2 RED TANKS ATTACK  1 BLUE TANK.        5 replications

        Range = 1500 meters

Time    ----------------EVENT----------------------
(sec)
        Skedul finish for entity  0 at time  600.00
        Skedul detect for entity  1 at time    1.24
        Skedul detect for entity  2 at time   18.24
        Skedul detect for entity  3 at time   20.16
  1.24  Blue  1 detects  Red   2
        Skedul firing for entity  1 at time   12.97
 12.97  Blue  1 fires at Red   2
        Skedul impact for entity 21 at time   14.01
        Cancel detect for entity  2 at time   18.24
        Skedul detect for entity  2 at time   12.97
        Skedul firing for entity  1 at time   26.36
 12.97  Red   2 detects  Blue  1
        Skedul firing for entity  2 at time   34.29
 14.01  Blue  1 F--kills Red  2
        Cancel firing for entity  2 at time   34.29
 20.16  Red   3 detects  Blue  1
        Skedul firing for entity  3 at time   36.36
 26.36  Blue  1 fires at Red   2
        Skedul impact for entity 21 at time   27.40
        Skedul firing for entity  1 at time   59.26
 27.40  Blue  1 misses   Red   2 8 loses round.
 36.36  Red   3 fires at Blue  1
        Skedul impact for entity 21 at time   37.27
        Skedul firing for entity  3 at time   43.26
 37.27  Red   3 misses   Blue  1 8 loses round.
 43.26  Red   3 fires at Blue  1
        Skedul impact for entity 21 at time   44.17
        Skedul firing for entity  3 at time   50.16
 44.17  Red   3 misses   Blue  1 8 loses round.
 50.16  Red   3 fires at Blue  1
        Skedul impact for entity 21 at time   51.07
        Skedul firing for entity  3 at time   57.06
 51.07  Red   3 misses   Blue  1 8 loses round.
 57.06  Red   3 fires at Blue  1
        Skedul impact for entity 21 at time   57.97
        Skedul firing for entity  3 at time   63.96
 57.97  Red   3 misses   Blue  1 8 loses round.
 59.26  Blue  1 fires at Red   2
        Skedul impact for entity 21 at time   60.30
        Skedul firing for entity  1 at time   75.48
 60.30  Blue  1 K--kills Red   2
        Cancel firing for entity  1 at time   75.48
        Skedul detect for entity  1 at time   60.84
 60.84  Blue  1 detects  Red   3
        Skedul firing for entity  1 at time   75.90
 63.96  Red   3 fires at Blue  1
        Skedul impact for entity 21 at time   64.87
        Skedul firing for entity  3 at time   70.86
 64.87  Red   3 misses   Blue  1 8 loses round.
 70.86  Red   3 fires at Blue  1
        Skedul impact for entity 21 at time   71.77
        Skedul firing for entity  3 at time   77.76
 71.77  Red   3 misses   Blue  1 8 loses round.
 75.90  Blue  1 fires at Red   3
        Skedul impact for entity 21 at time   76.94
        Skedul firing for entity  1 at time   91.88
 76.94  Blue  1 F--kills Red   3
        Cancel firing for entity  3 at time   77.76
 91.88  Blue  1 fires at Red   3
        Skedul impact for entity 21 at time   92.92
        Skedul firing for entity  1 at time  116.10
 92.92  Blue  1 hits     Red   3  but doesn't kill it.
116.10  Blue  1 fires at Red   3
        Skedul impact for entity 21 at time  117.14
        Skedul firing for entity  1 at time  133.84
117.14  Blue  1 K--kills Red   3
        Cancel firing for entity  1 at time  133.84
   .                      .
   .                      .
   .                      .
```

Switches can be set for further levels of detail which are not of interest here.

CLOSING COMMENTS

The model is written in FORTRAN IV and is reasonably portable. The code was written after the advent of Top Down Structured Programming so it is written in many small, well commented modules which use only structured constructs.

The model consists of about 30 pages of FORTRAN code and requires 64K words of memory.

For 500 replications of a case (which is reasonable number for convergence) the model runs on a time shared PDP 11/70 in about 30 minutes.

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